Rates of Reaction

SCH4U

Chemical Kinetics: Reaction Rates

Rate → change in a quantity over a given time interval

$$rate = \frac{\Delta quantity}{\Delta time}$$

Reaction Rates

Reaction rate → change in amount of reactants or products present in a system over a given period of time

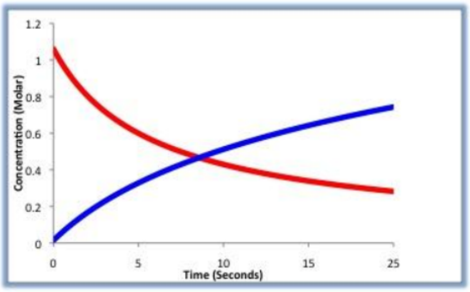
•Can be measured by either production of products or degradation of reactants

As a reaction proceeds:

As a reaction proceeds:

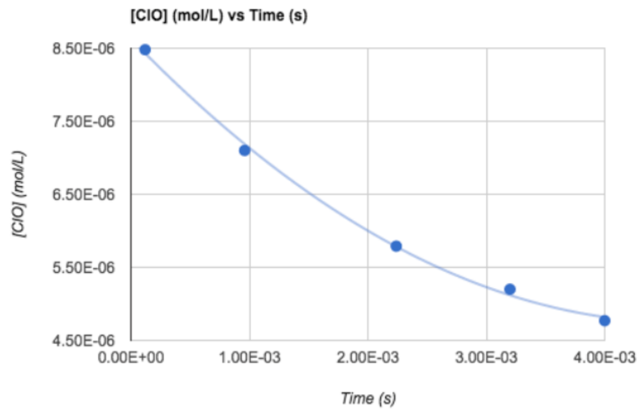
•Reactants are used up (decreased concentration in the system)

•Products are created (increased concentration in the system)



Does this graph show reactants or products?

How do you know?



Measuring reaction rate

Change in either concentration of reactants or products can be measured to indicate reaction progression (rate of reaction)

$$\therefore \; Reaction\ rate = \frac{[A]_{final} - [A]_{initial}}{t_{final} - t_{initial}} \quad \text{or} \quad Rate = \Delta[A]/\Delta t$$

Measuring Rates of Reaction

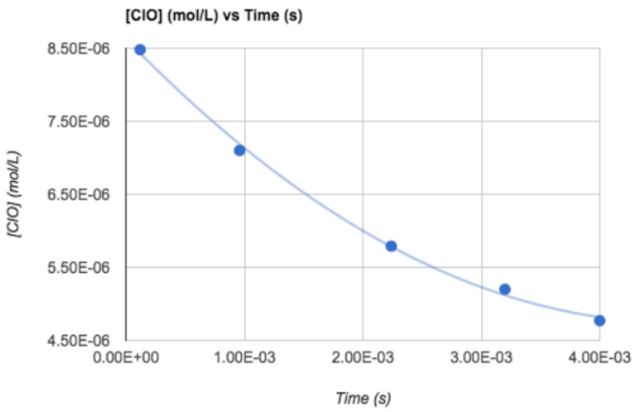
Average rate of reaction:

- A rate of reaction measured **over** any time interval $(= \Delta[A]/\Delta t)$

Measured as the slope between any two lines (secant)

Draw a secant line between $t = 9.60\times10^{-4}$ and $t = 2.24\times10^{-3}$

Calculate the average rate of reaction between those lines (slope of the secant)



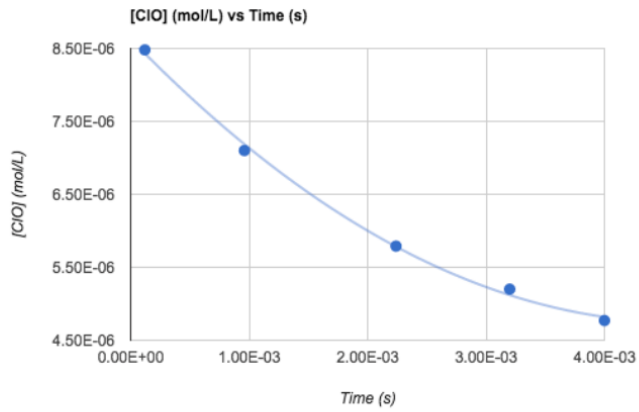
Instantaneous rate of reaction:

•Rate of a reaction **at** any given time

Measured as the slope of the line at that specific place (tangent)

Draw a tangent to the curve at t= 9.6E-4

Calculate the instantaneous rate of reaction at that point (slope of the tangent)



In a decomposition reaction represented by $2AB \rightarrow A_2 + B_2$, the concentration of product B_2 after 3.60min is 7.5×10^{-1} mol/L and after 4.80min 8.70×10^{-1}mol/L.

Calculate the average reaction rate, per second, in terms of B_2 between 3.60min and 4.80min.

Expressing reaction rates

When you measure the rate of change in quantity of one reactant or product, you can calculate the rate of change of all other reactants or products.

•Based on stoichiometric relationships (mole ratios)

Ex: $2NH_3(g) + 5/2O_2(g) \rightarrow 2NO(g) + 3H_2O(g)$

Chemical Kinetics Test- Friday, April 8

Rates of reactions (6.1)

Factors affecting reaction rates (6.2)

Reaction mechanisms (6.3)

Methods of measuring rates of reaction

All rates of reaction are determined experimentally:

- Measuring gas produced
- Measuring change in mass of reactant or product
- Temperature change
- Pressure in closed system
- Colour change
- pH change
- Electrical conductivity

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From these, we calculate moles (either produced or consumed) and compare them to time → mol/s

In an experiment, we collected 6ml of O_2 gas over 2 minutes at SATP. What was the rate of this reaction?

$$2MnO_4(aq) + 5H_2O_2(aq) + 6H^+(aq) \rightarrow 2Mn^{2+}(aq) + 8H_2O(l) + 5O_2(g)$$

Ex: You reacted 0.05g of Mg(s) in an excess of HCl. After 3 minutes, you removed the Mg strip from the system and it weighed 0.0034g. Calculate the reaction rate with respect to degradation of Mg(s).

$$Mg(s) + 2HCl(l) \rightarrow MgCl_2(aq) + H_2(g)$$

Collision Theory

In order for a reaction to proceed, the reactant particles must collide.

•More collisions per unit of time → faster reaction rate

However,

Not all collisions are **effective**

Effective Collisions

For a collision to result in a reaction, it must be effective.

Criteria for effective collisions :

1.Reactants must collide in a favourable geometry

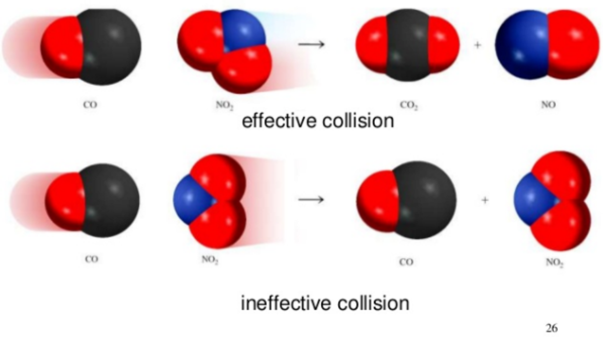
2.Collision must occur with sufficient energy

1. Reactants must collide with favourable geometry

Collision geometry

Importance of Molecular Orientation

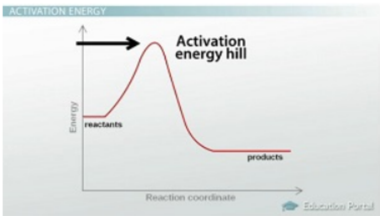
$CO(g) + NO_2(g) \longrightarrow CO_2(g) + NO(g)$



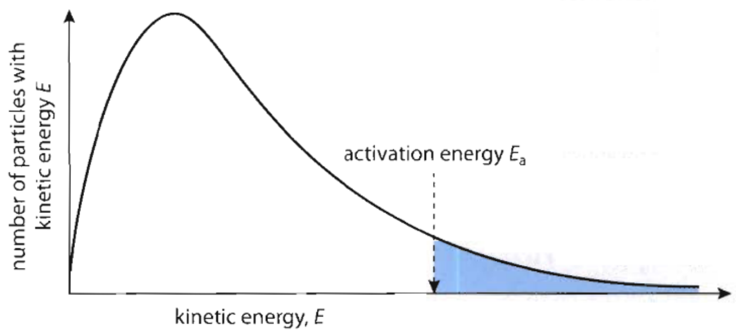
2. Collision must occur with sufficient energy

Must have enough energy to break any bonds in reactant particles.

•Activation energy (E_a) is minimum energy required for a reaction to take place.



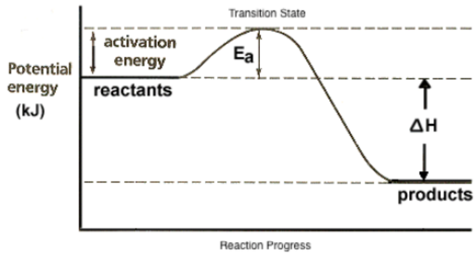
Collision energy = kinetic energy of colliding particles

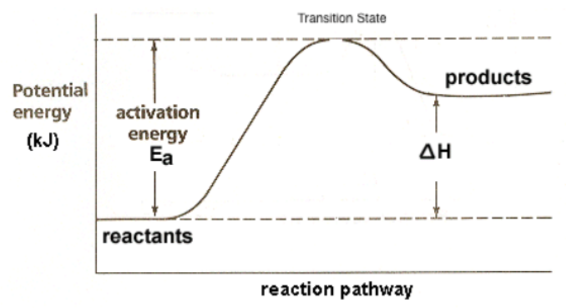


Representing progress of a reaction

Potential energy diagram:

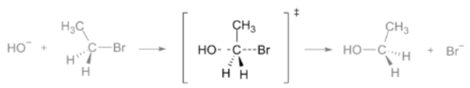
•Show changes in potential energy as a reaction progresses

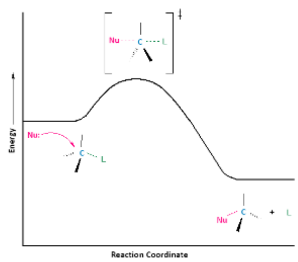



Transition State
products
Potential
energy
(kJ)
activation
energy
E_a
ΔH
reactants
reaction pathway

Transition State (aka "activated complex")

All chemical reactions go through a configuration of partial completion (transition) before they can progress to their product state. (*highest energy state)

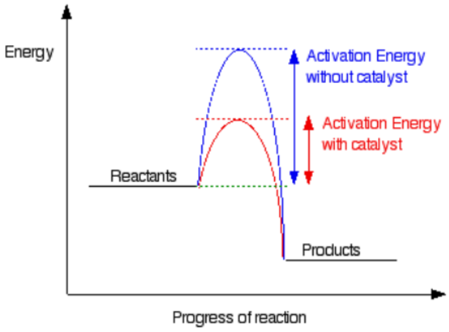




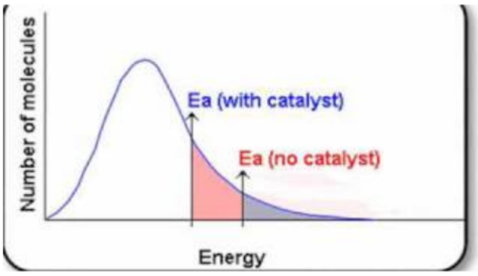
Catalysts

Catalyst:

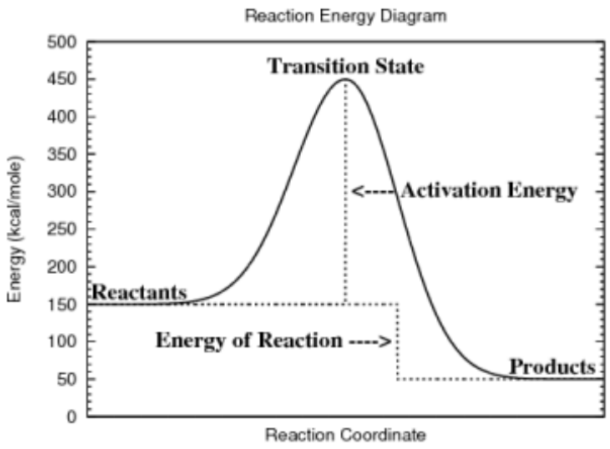
•Enzymes that decrease the activation energy of a reaction by providing alternate way of arriving at products



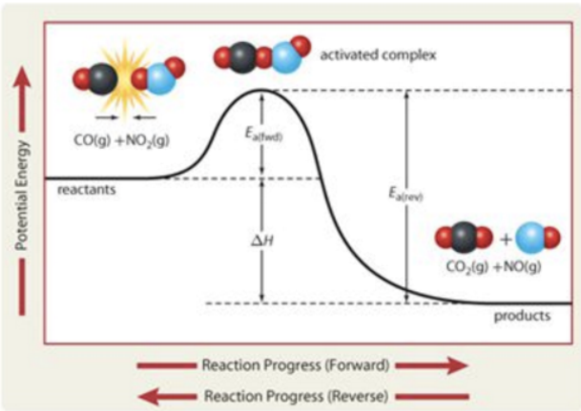
Catalysts impact the rate of reaction



Interpreting a PE diagram



Reversible reactions



Forward reaction read from L→ R

Reverse reaction read from R→L

$E_{a(fwd)} - E_{a(rev)} = \Delta H$

Practice Problem

p. 371 #18

When steam is passed over hot iron, a reaction occurs as shown below.

$3Fe(s) + 4H_2O(g) \leftarrow\rightarrow Fe_3O_4(s) + 4H_2(g)$ ΔH_r=-151.2kJ

The activation energy for the reverse reaction, $E_{a(rev)}$ is +200.71kJ.

a. Calculate the activation energy for the forward reaction.

b. Draw a labelled potential energy diagram showing the enthalpy change and the activation energies for the forward and reverse reactions.